IN VITRO BIOACTIVITIES OF ANODISED TITANIUM IN MIXTURE OF β-GLYCEROPHOSPHATE AND CALCIUM ACETATE FOR BIOMEDICAL APPLICATION

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ABSTRACT

Anodic oxidation has been widely used to modify the surface properties of titanium in order to improve the biocompatibility after implantation. In this study, high purity titanium foils were exposed in a mixture of β-glycerophosphate disodium salt pentahydrate (β-GP) and calcium acetate monohydrate (CA). The parameters for anodic oxidation method such as applied voltage (50-350 V), current density(10-70 $mA.cm^{-2}$), electrolyte concentration (0.02 M β-GP + 0.2 M CA, 0.04 M β-GP + 0.04 M CA) , anodising time (5-10 mins), agitation speed (300-1500 rpm), ultrasonic amplitude (20-60 μm) and bath temperature (4-100 °C) were varied to investigate the impact on the surface properties of titanium. The results showed that surface of the titanium foil appeared to be highly porous and demonstrated high crystallinity as well as high hydrophilic properties especially when the parameters of anodic oxidation have been varied. This study also proposes two novel methods particularly to accelerate the bone-like apatite formation on the anodised titanium in a shorted time: (1) UV irradiation during *in vitro* testing and (2) adding additives in electrolyte. After soaked and irradiated with UV in simulated body fluid (SBF) for 7 days, highly crystallised bone-like apatite was fully covered on the anodised surface. Interestingly, the smooth and partially porous surface of the anodised titanium was observed to be fully covered by the bone-like apatite layer, which contradict previous research results. The mechanism for growth of bone-like apatite was developed and involved several stages from the existence of hydroxyl groups (•OH) under the UV irradiation has been disclosed thoroughly. Further, additives such as sulphuric acid (H_2SO_4), hydrogen peroxide (H_2O_2) and sodium hydroxide (NaOH) were added into the electrolyte were also able to accelerate the formation of bone-like apatite because of the presence of (•OH), tricalcium phosphate ($Ca_3O_8P_2$), calcium diphosphate ($Ca_2O_7P_2$), calcium titanate ($CaTiO_3$) or sodium titanate ($Na_2Ti_3O_7$) on the anodised surface, which able to induce the nucleation site of bone-like apatite.

ABSTRAK

Pengoksidaan anod telah digunakan secara meluas untuk mengubahsuai sifat-sifat permukaan titanium bagi memperbaiki keserasian bio selepas implitasi. Dalam kajian ini, kerajang titanium berketulenan tinggi telah didedahkan di dalam campuran garam pentahidrat dinatrium β-gliserofosfat (β-GP) dan kalsium asetat monohidrat (CA). Parameter-parameter bagi langkah pengoksidaan anod seperti voltan gunaan (50-350 V), ketumpatan arus (10-70 $mA.cm^{-2}$), kepekatan elektrolit (0.02 M β-GP + 0.2 M CA, 0.04 M β-GP + 0.04 M CA), tempoh penganodan (5-10 mins), kelajuan agitasi (300-1500 rpm), amplitud ultrasonik (20-60 μm) dan suhu elektrolit (4-100 °C) telah diambil kira bagi mengkaji kesan terhadap sifat-sifat permukaan titanium. Permukaan kerajang titanium didapati mempunyai liang yang banyak dan menunjukkan kekristilan serta sifat hidrofilik yang tinggi terutama semasa parameter-parameter pengoksidaan anod telah diubah-ubah. Kajian ini turut mencadangkan dua kaedah baru bagi mempercepatkan pembentukan apatit berbentuk tulang pada titanium yang sudah dianodkan dalam masa yang singkat : (1) penyinaran UV semasa ujian *in vitro* dan (2) peletakan bahan tambahan dalam campuran β-GP + CA. Setelah direndam dan didedahkan dengan UV di dalam SBF selama 7 hari, didapati apatit berbentuk tulang tinggi kekristilan telah dilitupi pada permukaan titanium yang sudah dianodkan. Permukaan titanium tersadur yang licin dan sebahagiannya berliang didapati telah dilitupi sepenuhnya dengan lapisan apatit berbentuk tulang bertentangan dengan dapatan yang. Mekanisma bagi pertumbuhan apatit berbentuk tulang telah dibangunkan dan melibatkan beberapa peringkat bermula dari kewujudan kumpulan hidroksil (•OH) di bawah sinaran UV telah dilampirkan. Bukan itu sahaja, bahan tambahan seperti asid sulfuric (H_2S0_4), hidrogen peroksida (H_2O_2) dan natrium hidroksida (NaOH) ke dalam elektrolit juga berkemampuan untuk mempercepatkan pembentukan apatit berbentuk tulang disebabkan oleh kewujudan kumpulan hidroksil (•OH), trikalsium fosfat ($Ca_3O_8P_2$), di-kalsium difosfat ($Ca_2O_7P_2$), kalsium titanat

($CaTiO_3$) atau natrium titanat ($Na_2Ti_3O_7$) yang berkebolehan untuk mendorong pembentukan tapak penukleusan apatit berbentuk tulang telah dianodkan pada permukaan titanium.

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